



# PATENT SPECIFICATION

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## COMPLETE SPECIFICATION

### Improvements in or relating to Dust Separators of the Cyclone Type.

We, JONES GAS PROCESS COMPANY LIMITED, a British Company, of The Gas Works, Gloucester Road, Cheltenham, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to dust separators 10 of the cyclone type as commonly employed for the extraction of dust from dust-laden gas or vapour. It is of special advantage when applied to cyclones used for the extraction from gas of fine "sticky" dust, such for example as 15 carbon black, the particles of which tend to cohere and form deposits.

In the operation of separators of the cyclone type the dust-laden gas stream is caused to enter the substantially cylindrical cyclone 20 chamber in a more or less tangential direction, extraction of the dust from the gas stream being achieved by reason of the centrifugal force set up by the whirling of the stream of gas in its flow through the cyclone 25 chamber which throws the dust to the wall of the latter. It is generally accepted that during operation a thin layer of relatively still gas is established between the wall of the cyclone and the whirling gas stream and that 30 when the dust particles reach this layer they are virtually separated and, unless subsequently re-trained, will eventually fall to the bottom of the cyclone where they can be discharged through the central dust outlet 35 provided in the conical lower portion of the cyclone.

Apart from considerations of size and gas velocities the separating efficiency of a cyclone depends to a large extent on the number of 40 "turns" which the gas makes round its cylindrical wall before leaving the cyclone by way of the gas outlet which is usually in the form of a pipe coaxially arranged in the upper end of the cyclone. In other words the longer 45 the path of the gas around the cyclone wall

the greater is the chance of dust particles which are furthest away from the cyclone wall at the inlet reaching the wall. For this reason the coaxial gas outlet pipe is usually caused to dip into the cyclone in order to ensure that 50 the gas makes a greater number of effective turns, in that it is bound to flow downwardly to reach the outlet. However, on completion of one turn round the cyclone the flowing gas meets the incoming stream which results in 55 a high pressure loss and also sets up a turbulence whereby, despite the fact that the flow of gas within the cyclone is eventually helically downwards, this is not accomplished smoothly and accordingly the effectiveness of 60 the increased length of path of the gas stream is thereby reduced.

In order to reduce the interference due to the flowing gas stream meeting the incoming stream at the inlet, the inlet pipe of the cyclone is sometimes arranged so that, instead of its outer wall being disposed substantially tangentially to the wall of the cyclone, its inner wall is so tangentially disposed, the straight parallel portion of the outer wall of 70 the inlet pipe passing at its inner end into a volute-shaped wall portion or scroll which gradually merges into the cylindrical wall of the cyclone at a point substantially diametrically opposite so that the gas is guided 75 gradually into a path within such cylindrical wall. However, in that arrangement, although on completion of one turn round the cyclone wall the gas stream is parallel to the incoming 80 stream and consequently does not set up turbulence to as great an extent as would otherwise be the case, and does not result in such a high pressure loss, the gas still has a tendency to turn upon itself and has to find its own way in a helical path before leaving 85 by way of the coaxial gas outlet pipe. Furthermore when cyclones are employed for the separated by a fine "sticky" dust, there is a tendency for deposits to form under the top plate 90 of the cyclone in "dead" spots which increase 90

turbulence and reduce separating efficiency unless the deposits are removed at frequent intervals.

The present invention has for its main object to avoid these disadvantages and difficulties and to provide an improved construction of cyclone in which the dust-laden gas will take the longest practical helical path through the cyclone substantially without interference whereby high separating efficiency with low pressure loss will result. A further object is to obtain these results and advantages while maintaining the cyclone of simple form, as is necessary from the maintenance point of view.

According to the invention the inlet pipe of a dust separator of the cyclone type is constructed to slope downwardly to the top plate or head of the cyclone in order to direct the gas stream on its helical path down the cyclone, the angle of slope being such that on completion of one turn round the cyclone the gas stream is immediately below the incoming stream. By this means the second and subsequent turns are made without interference with the gas flow in the preceding turn, the guiding effect being increased by constructing the top plate or head of the cyclone chamber itself of helical form with the inner end of the inlet pipe merging smoothly into such helix. The coaxial gas outlet pipe dips into the cyclone chamber so that the gas stream is guided on its first turn round the cyclone by the inner surface of the cylindrical wall of the cyclone, by the outer surface of gas outlet pipe and by the inner surface of the helical top plate or head.

By causing the gas outlet pipe to dip into the cyclone chamber in conjunction with the helical formation of the top plate or head a considerably higher degree of definition of the cross-sectional area of flow of the gas stream on its first turn round the cyclone is achieved than if a non-entrant gas outlet pipe were employed, only the lower side of such flow area being left undefined in order to avoid the necessity for built-in walls or guide surfaces which are impractical in the case of cyclones which have to be lined in view of the temperature of the gas stream to be treated.

Preferably the inlet pipe is of substantially the same width at its inner end as the radial distance between the cylindrical wall of the cyclone and the wall of the coaxial gas outlet pipe. Thus, the cross-sectional area of the inlet pipe, which is preferably substantially rectangular, is substantially the same as the effective cross-sectional area of flow of the gas stream on its first turn round the cyclone so that smooth passage of the gas stream from the inlet pipe into its first turn round the cyclone is assured, the lower end of the helical top plate or head terminating adjacent the lower edge of the inner wall of the inlet pipe.

In order to secure higher efficiencies of separation of ultra-fine and light dusts, and at the expense of somewhat increased pressure loss, a minor departure may be made from the arrangement in which the gas stream passes smoothly from the inlet pipe into its first turn round the cyclone, as will be described in detail hereinafter.

The application of the invention to a cyclone for separating fine carbon black from the hot gas stream resulting from the thermal decomposition of liquid hydrocarbons is illustrated, by way of example, in the accompanying drawings, in which:—

Fig. 1 is a vertical elevation of the cyclone and of an associated dust-collecting hopper,

Figs. 2 and 3 are a section and a part-sectional elevation of the upper portion of the cyclone on the lines II—II and III—III respectively of Fig. 1, and

Fig. 4 is a part-sectional plan on the line IV—IV of Fig. 1 and showing in chain-dotted lines an alternative shaping of the inner end of the inlet pipe of the cyclone.

Referring to the drawings, the cylindrical wall 10 of the cyclone and the inlet pipe 11 are preferably constructed of mild steel and both are provided with a lining 12 of a refractory material such, for example, as an aluminous cement. The gas outlet pipe 13, which is of cylindrical form and coaxially arranged in the top plate or head 14 of the cyclone, is preferably constructed of stainless steel and dips into the cyclone chamber, as illustrated in Figs. 1, 2 and 3. At its lower end the wall 10 of the cyclone chamber is of conical shape, as shown at 10a in Fig. 1, and is provided with a coaxial dust outlet 15 leading to a dust-collecting hopper 16 having a discharge gate 17, the hopper 16 being of the construction usually employed to prevent re-entrainment of the dust. The gas outlet 13 is provided with a coaxial outer tube 13a which terminates a short distance inwardly of the top plate or head 14 in an outwardly turned flange 13b, as shown in Fig. 2, to form a key for the refractory lining 12 with which the top plate or head is also provided. The cylindrical wall 10, top plate or head 14 and inlet pipe 11 are thus all lined with the refractory material, only the stainless steel gas outlet pipe 13 being left unlined.

The inlet pipe 11 is of approximately rectangular cross-section throughout its length from the flange 11a at its outer end, as illustrated in Figs. 3 and 4, and is of substantially the same internal width, i.e., the distance between the inside of the refractory lining 12 of its vertical walls, as the radial distance between the cylindrical wall of the gas outlet pipe 13 and the inside of the cylindrical wall 10 of the cyclone, or rather the inside 12c of the lining 12 of the latter, all as clearly illustrated in Fig. 4. It will be seen that in relation to the cylindrical wall of the gas outlet 13

pipe 13 the inner surface of the inlet pipe lining (indicated at 12a in Figs. 3 and 4) is substantially tangentially disposed the inside surface 12b of the lining of the outer vertical wall of the inlet pipe being tangential to the cylindrical wall 10 of the cyclone, or rather to the inside 12c of the refractory lining of the latter. The inlet pipe 11 slopes downwardly from its flange 11a, i.e., from a point 10 outside the cylindrical wall 10 of the cyclone, and at its inner end has its upper wall merging smoothly into the adjacent portion of the substantially annular top plate or head 14 of the cyclone, as shown in Fig. 1, such top plate or head being of helical form and having its lower end 14a, Figs. 3 and 4, terminating adjacent the inner wall of the inlet pipe 11. It will be seen from Fig. 1 that the helix angle of the top plate or head 14 is substantially the same as the angle of slope of the inlet pipe 11; moreover it is such that the lining 12 at the lower end 14a of the top plate or head is at about the same level as the inner surface 12d, Fig. 3, of the refractory lining 12 of the lower wall of the inlet pipe. As shown in Figs. 1 and 3 these lining surfaces merge at the point 12e.

Along its inner edge the top plate or head 14 has the cylindrical wall of the gas outlet pipe 13, or rather the wall of the outer tube 13a, welded or otherwise secured thereto, the weld line being, of course, in the form of a helix 13c, Figs. 2 and 3, extending down the wall of the gas outlet pipe. The top plate or head of the cyclone constitutes a helical vane beneath which the hot gas stream is smoothly directed by the inlet pipe 11 which continues the line of slope of the helix outside the cylindrical wall 10 of the cyclone, as already described. Thus, the hot gas is guided on its helical path down the cyclone chamber for one turn while the second turn closely underlies the first, thereby providing, within practical limits, the maximum length of path for 45 the gas stream through the chamber, the increased length of helical travel being accomplished smoothly and without the overlapping of convergent gas streams.

As will be seen from the drawings, this 50 guiding of the gas stream which is initiated by the downwardly sloping inlet pipe 11 and continued for one complete turn round the cyclone chamber immediately below the top plate or head 14 of the latter is achieved 55 without recourse to built-in walls or guide surfaces, which are impractical in refractory-lined cyclones. Nevertheless the guiding effect is powerful in that the substantially rectangular cross-sectional area of flow in the 60 inlet pipe 11 (defined by the inner surfaces 12a, 12d, 12b, 12f, Fig. 3, of the refractory lining of the latter) is continued within the cyclone chamber by the surface of the outlet pipe 13, the inside surfaces 12c of the lining 65 of the cylindrical wall 10 of the cyclone and

the inside surface 12g, Figs. 2 and 3, of the lining of the top plate or head 14, only the lower side of the rectangular cross-sectional area of flow being left undefined. The lower wall of the inlet pipe 11 terminates at the cylindrical wall 10 of the cyclone, i.e., along the circular arc extending between w and v in Fig. 4, the inner surface 12a of the lining of such lower wall likewise terminating at the surface 12c of the lining of the cylindrical wall 10, i.e., along the arc between y and z, while the inner vertical wall of the inlet pipe terminates at the outlet pipe 13, or rather at the outer tube 13a of the latter, as shown in Fig. 4 and by the line v in Fig. 1. In like 80 manner to that already described, the surface 12a of the lining of such inner vertical wall also terminates substantially at the outer tube 13a, as clearly illustrated in Fig. 4, in order to ensure smooth passage of the gas stream from 85 the inlet pipe into its first turn round the cyclone.

By the means described interference in the vicinity of the inlet pipe 11 is eliminated whereby pressure loss is reduced together 90 with the resulting turbulence and subsequent re-entrainment of dust around the coaxial gas outlet pipe 13, separating efficiency being accordingly increased. Moreover, despite the fine "sticky" nature of the carbon black, the 95 particle size of which may range from 80 to 300μ, deposits under the top plate or head 14 of the cyclone are reduced or completely avoided due to the fact that this surface is completely swept by the entering gas stream 100 and there are subsequently no "dead" spots where the carbon black can build up and set up turbulence.

Referring to Fig. 4, the element or vane 105 illustrated in chain-dotted lines therein is provided to give an alternative or modified shape to the inner end of the inlet pipe 11. It may be formed as part of the refractory lining 12 or else as a separate detachable insert 110 of heat-resisting steel and is only employed 110 to increase the efficiency of separation of ultra-fine and -light dusts and with the consequential disadvantage of a somewhat higher pressure loss in the system.

The process of carbon black production 115 by cyclical the refractory lining 12 of the cyclone chamber and inlet pipe enables condensation of steam and oily vapours on the walls to be prevented between runs. Moreover the refractory lining also retains sufficient 120 heat to prevent condensation on the initial runs after a short plant-maintenance shut down.

What we claim is:—

1. A dust separator of the cyclone type 125 wherein the inlet pipe is constructed to slope downwardly to the top plate or head of the cyclone in order to direct the gas stream on its helical path down the cyclone, the angle of slope being such that on completion of one 130

ture round the cyclone the gas stream is immediately below the incoming stream, and wherein the guiding effect initiated by the slope of the inlet pipe is continued by constructing the 5 top plate or head of the cyclone chamber itself of helical form with the inner end of the inlet pipe merging smoothly into such helix, the coaxial gas outlet pipe dipping into the cyclone chamber so that the gas stream 10 is guided on its first turn round the cyclone by the inner surface of the cylindrical wall of the cyclone, by the outer surface of the gas outlet pipe and by the inner surface of the helical top plate or head.

15 2. A dust separator according to Claim 1, wherein the cross-sectional flow area of the inlet pipe is substantially the same as the effective cross-sectional area of flow of the gas stream on its first turn round the cyclone, 20 i.e., as the area of the rectangle defined on three sides by the inner surface of the cylindrical wall of the cyclone, by the outer surface of the gas outlet pipe and by the inner surface of the helical top plate or head.

25 3. A dust separator according to Claim 1 or 2, wherein the inlet pipe is of substantially rectangular shape in cross-section and is of substantially the same width as the radial distance between the cylindrical wall of the 30 cyclone and the wall of the gas outlet pipe the inner vertical wall of the inlet pipe being substantially tangentially disposed to the wall of the gas outlet pipe and the outer vertical wall of the inlet pipe being substantially tan- 35 gentially disposed to the cylindrical wall of the cyclone.

4. A dust separator according to Claim 3, wherein the helical slope of the top plate or head is substantially the same as the down- 40 ward slope of the inlet pipe which commences at a point outside the cylindrical wall of the cyclone, the arrangement being such that the upper wall of the inlet pipe merges smoothly into the top plate or head while its lower wall 45 terminates at the cylindrical wall of the cyclone whereby the gas stream is guided throughout its first turn round the cyclone by the inner surface of the cylindrical wall of the cyclone, by the outer surface of the gas outlet 50 pipe and by the inner surface of the helical

top plate or head only.

5. A dust separator according to any of the preceding claims, wherein the lower end of the top plate or head terminates adjacent the inner wall of the inlet pipe at about the 55 same level as the bottom of said inlet pipe.

6. A dust separator according to any of Claims 3 to 5, wherein the inlet pipe, cylindrical wall of the cyclone and the top plate or head of the latter are all provided with a lining 60 of refractory material and wherein said inner surface of the cylindrical wall of the cyclone and said inner surface of the helical top plate or head are the inner surfaces of said lining while said inner and outer vertical walls of the inlet pipe are the corresponding inner surfaces of said lining.

7. A dust separator according to Claim 6, wherein the gas outlet pipe is of heat-resisting steel and is provided with a coaxial 70 outer tube which terminates a short distance inwardly of the top plate or head where it forms a key for the refractory lining of said top plate or head.

8. A dust separator according to any of the preceding claims, wherein an element or vane is provided to give an alternative or modified shape to the inner end of the inlet pipe, substantially as and for the purpose specified.

9. Means for separating fine carbon black 80 from a hot gas stream in which it is suspended, said means comprising a dust separator of the cyclone type according to any of the preceding claims.

10. A dust separator of the cyclone type 85 constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

11. Means for separating fine carbon black from the hot gas stream resulting from the 90 thermal decomposition of liquid hydrocarbons, said means being substantially as herein described with reference to the accompanying drawings.

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## PROVISIONAL SPECIFICATION

### Improvements in or relating to Dust Separators of the Cyclone Type.

95 We, JONES GAS PROCESS COMPANY LIMITED, a British Company, of The Gas Works, Gloucester Road, Cheltenham, do hereby declare this invention to be described in the following statement:—

100 This invention relates to dust separators of the cyclone type as commonly employed for the extraction of dust from dust-laden gas or vapour. It is of special advantage when

applied to cyclones used for the extraction from gas of fine "sticky" dust, such for example as carbon black, the particles of which tend to cohere and form deposits.

In the operation of separators of the cyclone type the dust laden gas stream is caused to enter the substantially cylindrical cyclone chamber in a more or less tangential direction, extraction of the dust from the gas

stream being achieved by reason of the centrifugal force set up by the whirling of the stream of gas in its flow through the cyclone chamber which throws the dust to the wall 5 of the latter. It is generally accepted that during operation a thin layer of relatively still gas is established between the wall of the cyclone and the whirling gas stream and that when the dust particles reach this layer they 10 are virtually separated and, unless subsequently re-entrained, will eventually fall to the bottom of the cyclone where they can be discharged through the central dust outlet provided in the conical lower portion of the 15 cyclone.

Apart from consideration of size and gas velocities the separating efficiency of a cyclone depends to a large extent on the number of "turns" which the gas makes round its 20 cylindrical wall before leaving the cyclone by way of the gas outlet which is usually in the form of a pipe coaxially arranged in the upper end of the cyclone. In other words the longer the path of the gas around the cyclone wall the 25 greater is the chance of dust particles which are furthest away from the cyclone wall at the inlet reaching the wall. For this reason the coaxial gas outlet pipe is usually caused to dip into the cyclone in order to ensure that 30 the gas makes a greater number of effective turns, in that it is bound to flow downwardly to reach the outlet. However, on completion of one turn round the cyclone the flowing gas meets the incoming stream which results 35 in a high pressure loss and also sets up turbulence whereby, despite the fact that the flow of gas within the cyclone is eventually helically downwards, this is not accomplished smoothly and accordingly the effectiveness of 40 the increased length of path of the gas stream is thereby reduced.

In order to reduce the interference due to the flowing gas stream meeting the incoming stream at the inlet, the inlet pipe of the cyclone is sometimes arranged so that, instead of 45 its outer wall being disposed substantially tangentially to the wall of the cyclone, its inner wall is so tangentially disposed, the straight parallel portion of the outer wall of 50 the inlet pipe passing at its inner end into a volute-shaped wall portion or scroll which gradually merges into the cylindrical wall of the cyclone at a point substantially diametrically opposite so that the gas is guided gradually 55 into a path within such cylindrical wall. However, in that arrangement, although on completion of one turn round the cyclone wall the gas stream is parallel to the incoming stream and consequently does not set up turbulence to as great an extent as would otherwise 60 be the case, and does not result in such a high pressure loss, the gas still has a tendency to turn upon itself and has to find its own way in a helical path before leaving by 65 way of the coaxial gas outlet pipe. Further-

more when cyclones are employed for the separation of fine "sticky" dust, there is a tendency for deposits to form under the top plate of the cyclone in "dead" spots which increase turbulence and reduce separating efficiency unless the deposits are removed at frequent intervals. 70

The present invention has for its main object to avoid these disadvantages and difficulties and to provide an improved construction of cyclone in which the dust-laden gas will take the longest practicable helical path through the cyclone substantially without interference whereby high separating efficiency with low pressure loss will result. A further 75 object is to obtain these results and advantages while maintaining the cyclone of simple form, as is necessary from the maintenance point of view. 80

According to the invention the inlet pipe of 85 a dust separator of the cyclone type is constructed to slope downwardly to the top plate or head of the cyclone in order to direct the gas stream on its helical path down the cyclone, the angle of slope being such that on completion 90 of one turn round the cyclone the gas stream is immediately below the incoming stream. By this means the second and subsequent turns are made without interference with the gas flow in the preceding turn, the 95 guiding effect being preferably increased by constructing the top plate or head of the cyclone chamber itself of helical form with the inner end of the inlet pipe merging smoothly into such helix. 100

Preferably the inlet pipe is of substantially the same width at its inner end as the radial distance between the cylindrical wall of the cyclone and the wall of the coaxial gas outlet pipe. Thus, the cross-sectional area of the 105 inlet pipe, which is preferably substantially rectangular, is substantially the same as the effective cross-sectional area of flow of the gas stream on its first turn round the cyclone, the lower end of the helical top plate or head 110 terminating adjacent the lower edge of the inner wall of the inlet pipe.

In carrying the invention into effect in conjunction with a cyclone for separating fine carbon black from the hot gas stream resulting 115 from the thermal decomposition of liquid hydrocarbons the cylindrical wall of the cyclone and the inlet pipe are preferably constructed of mild steel and the whole lined with a refractory material such, for example, as an 120 aluminous cement. The gas outlet pipe, which is of cylindrical form and coaxially arranged in the top plate or head of the cyclone, is preferably constructed of stainless steel and dips into the cyclone chamber. At 125 its lower end the latter is of conical shape and is provided with a coaxial dust outlet in the usual manner.

The inlet pipe is of rectangular cross-section and at its inner end is of substantially the same 130

width as the radial distance between the cylindrical wall of the gas outlet pipe and the cylindrical wall of the cyclone. In relation to the cylindrical wall of the gas outlet pipe the inner 5 vertical wall of the inlet pipe is substantially tangentially disposed, the outer vertical wall of the inlet pipe being tangential to the cylindrical wall of the cyclone, or rather to the inside of the refractory lining of the latter. The 10 inlet pipe slopes downwardly and merges smoothly into the adjacent portion of the substantially annular top plate or head of the cyclone, such top plate or head being of helical form and having its lower end terminating 15 adjacent the inner wall of the inlet pipe at about the same level as the inner surface of the refractory lining of the lower horizontal wall of the latter.

Along its inner edge the top plate or head 20 has the cylindrical wall of the gas outlet pipe welded or otherwise secured thereto, the weld line being, of course, in the form of a helix extending down the wall of the gas outlet pipe. The top plate or head of the cyclone 25 constitutes a helical vane beneath which the hot gas stream is smoothly directed by the inlet pipe which continues the line of slope of the helix. Thus, the hot gas is guided on its helical path down the cyclone chamber for one turn 30 while the second turn closely underlies the first, thereby providing, within practical limits, the maximum length of path for the gas stream

through the chamber, the increased length of helical travel being accomplished smoothly and without the overlapping of convergent gas 35 streams. By this means interference in the vicinity of the inlet pipe is eliminated whereby pressure loss is reduced together with the resulting turbulence and subsequent re-entrainment of dust around the coaxial gas outlet 40 pipe, separating efficiency being accordingly increased. Moreover, despite the fine "sticky" 45 nature of the carbon black, the particle size of which may range from 80 to 300mu, deposits under the top plate or head of the cyclone are reduced or completely avoided due to the fact that this surface is completely swept by the entering gas stream and there are consequently no "dead" spots where the carbon black can 50 build up and set up turbulence.

The process of carbon black production being cyclical the refractory lining of the cyclone chamber and inlet pipe enables condensation of steam and oily vapours on the wall to be prevented between runs. Moreover the refractory lining also retains sufficient heat to prevent condensation on the initial runs after a short plant-maintenance shut down.

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**762,070 COMPLETE SPECIFICATION**  
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